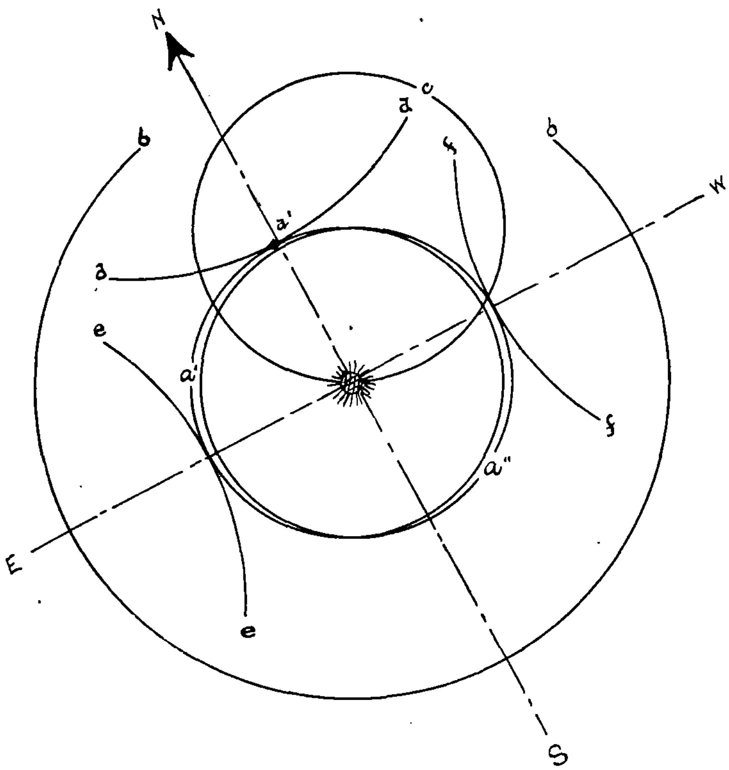

FIG. 2.—*a′ a″* Complete circles of 22°, with intensely bright prismatic colors (red on inside). The space about the sun encircled by these halos was darkened to a considerable degree.

b b A portion of a circle of 45°, also in prismatic colors (red on inside), though not so bright.

c A complete circle, white in color, having for its center the upper intersection of *a′ a″* and passing through the sun.

d d A segment, white in color, apparent radius 45°, which joined *a″*, showing a faint parhelion (*d′*) at junction.

e f Similar segments to the foregoing, without parhelia.

The radii were estimated without instruments; the bearing was taken by means of the direction arms of the station anemoscope.

LAKE LEVELS AND WIND PHENOMENA.[1]

By ALFRED J. HENRY, Professor of Meteorology.

Through the courtesy of the officials of the Engineer Corps, United States Army, in charge of the survey and improvement of the Great Lakes, we have been furnished with a continuous record of the fluctuations in lake level for several months past, at Amherstburg, Ontario, mouth of the Detroit River, and Buffalo Harbor, Lake Erie. These records, in conjunction with the continuous records of wind direction and velocity and atmospheric pressure made at the Weather Bureau offices in Detroit and Buffalo, furnish the material for a study of the mechanical effect of the wind in raising and lowering the level of the lake at the points above named.

It has been known for some years that general winds, as distinguished from local winds, blowing parallel to the longer axis of the main body of the lake, have a tendency to heap up the water at the end of the lake toward which they blow, and to depress it at the opposite end. Owing to the convergence of the shore lines at Buffalo the heaping up of the waters in that harbor, under the influence of a southwesterly wind, becomes a serious menace to the safety of wharf and dock property. Likewise, owing to the shoal water at either end of the lake, a decrease in the available depth in the harbors and channels produces vexatious delays and frequent groundings.

As a first attempt to correlate atmospheric phenomena and fluctuations of lake level, we have platted the data of wind direction and velocity at the Weather Bureau stations of Buffalo and Detroit, and the fluctuations of lake level as registered by the gages maintained by the Engineer Corps at Buffalo and Amherstburg, respectively, for March, 1900. The record for the entire month can not be reproduced on this chart, but we present in the accompanying diagrams the curves for March 4 to 10, and from noon of March 22 to noon of March 29. The first diagram (Fig. 3) illustrates the fluctuations in lake level consequent upon the passage of a storm moving from the Mississippi Valley northeasterly across the Lake region. It will be noticed, having reference particularly to that portion of the diagram included between 4 a. m. of the 5th and 4 a. m. of the 7th, that at Amherstburg the water first rose then fell and rose again, and that the oscillations at Buffalo were almost the exact converse of those at Amherstburg.

The fall in level at Buffalo and the corresponding rise at Amherstburg are due, as is generally known, to the northeasterly winds in front of the advancing storm. As the storm center passes Amherstburg, let us say, the wind shifts or backs, as the case may be, to a westerly quarter; likewise, as the storm center advances successively from point to point between Amherstburg and Buffalo, the winds along the line of movement of the storm center also change direction from an easterly to a westerly quarter. When the shift of wind occurs the water is above the mean level at the western end of the lake and below at the opposite end. The new impulse given to the lake waters by the westerly winds generates a second oscillation in a direction contrary to the first, viz, from west to east, and the cycle of changes is completed when the water finally returns to the level it had before the advent of the storm. The amplitude of the oscillations may reach an extreme value of 6 or 7 feet, but, in general, it is considerably less.

The records thus far obtained show that the oscillations do not occur with all storms, and that a given wind velocity does not necessarily produce a corresponding change in water level.

The period of the oscillation depends largely upon the time the easterly winds prevail, since there will be no reflex movement of the water until the wind changes to a westerly quarter. When this change takes place the concluding phase of the oscillations seems to occupy from twelve to sixteen hours, notwithstanding the fact that the wind may persist at a high velocity.

The second diagram (Fig. 4) is in some respects similar to the first. It, too, illustrates the passage of a storm, but with this important difference, viz, the center of the storm passed due east across Lake Erie and the wind *backed* to the northwest instead of shifting to the southwest, as in the first storm. The velocity of the wind was not nearly so high as in the first case. The northeasterly winds of the second storm caused an elevation of the waters at Amherstburg and a depression at Buffalo, as in the first storm, but here the similarity of the phenomena ends. The impulse given the water by the northwest winds seems to have created a transverse rather than a longitudinal oscillation; that is to say, an oscillation across the lake from the Canadian to the American shore, instead of lengthwise of the lake, as happens with northeasterly winds. It will also be noticed that the period of the oscillations from about 4 p. m. of the 26th to noon of the 27th is shorter than that of the succeeding days and at other times when longitudinal oscillations prevail, as might be expected. The oscillations from 6 p. m. of the 27th to noon of the 29th appear to be characteristic of fair weather, with light to moderate winds. The synchronism of the times of high water at Amherstburg and low water at Buffalo, and vice versa, is almost perfect. The period of oscillation is likewise fairly constant, ranging from six to eight hours for a half oscillation and from twelve to sixteen hours for a whole oscillation. The computed time of a whole oscillation, assuming the lake to have a mean depth of 50 feet, is, roughly speaking, seventeen hours.

While the information on the subject is as yet too fragmentary to admit of drawing trustworthy conclusions, this much seems to be apparent: The oscillations are stationary rather than progressive. A wave of water is not propagated, in the ordinary sense of that word, from one end of the lake to the other, but the whole lake oscillates about a pivotal or nodal line, which, in the case of longitudinal oscillations, may be said to cross the lake about the longitude of Fairport, Ohio. Although we have no instrumental evidence of the fact, it may be assumed that, as in the case of similar oscillations in other landlocked bodies of water, the oscillations at the nodal line are zero, increasing to a maximum at the respective ends of the lake. Dangerous currents in midlake are not likely to be engendered by these temporary oscillations.

It is within the range of probability that the occurrence of the more pronounced oscillations can be forecast by the Weather Bureau at no distant period.

[1] Reprinted from the Lake Chart for July, 1900.

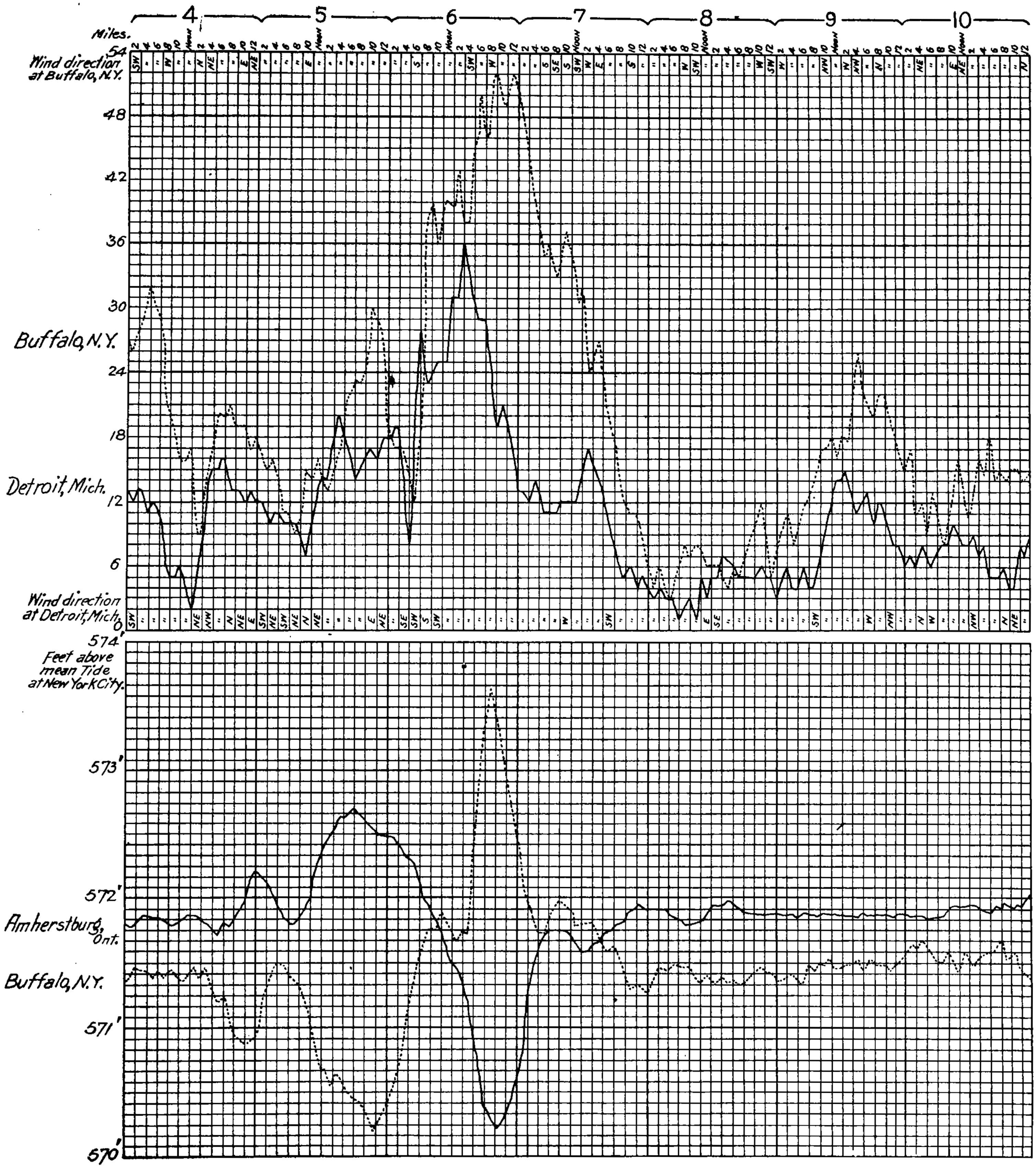

FIG. 3.—Oscillations in lake level and wind phenomena, March 4–10, 1900.

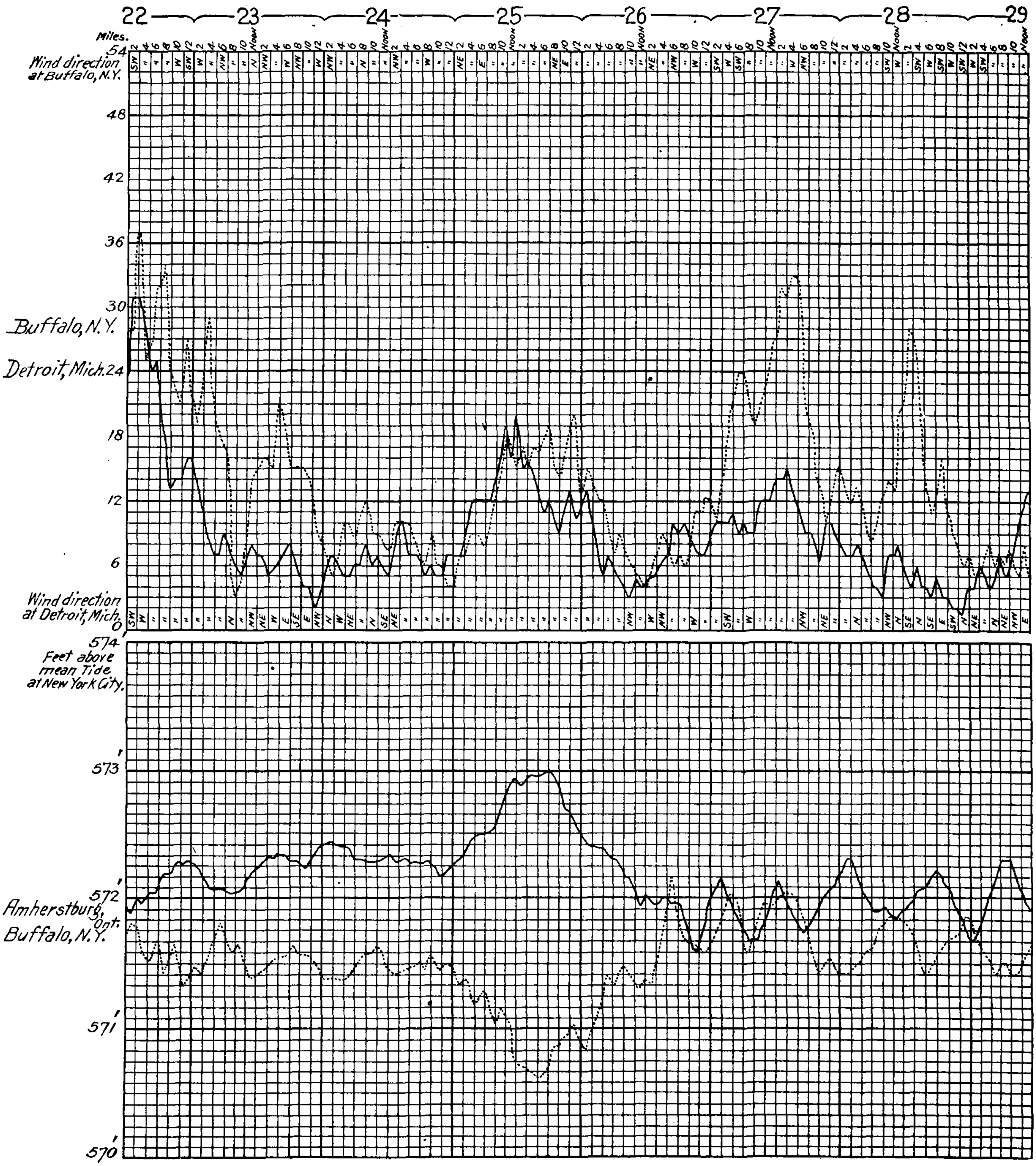

FIG. 4.—Oscillations in lake level and wind phenomena, March 22-29, 1900.